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UNIVERSITY OF *Minnesota*

COLLEGE OF BIOLOGICAL SCIENCES
DEPARTMENT OF BIOCHEMISTRY • ST. PAUL, MINNESOTA 55101

July 19, 1967

To the members of panel #23

From H. Orin Halvorson

I am enclosing a final draft of our report and I hope you will all find this acceptable. There are two sections omitted because we are awaiting data from the Army concerning military losses in recent wars and as soon as this is available we will finish these two sections.

This final draft will be submitted to the Central Committee and if you have any suggestions for additions you may send them to me so I can incorporate them into the final draft before the time of the Central Committee meeting in the later part of August.

I would like to have a list of the persons that have served as consultants to the panel so their names can be listed at the end of the report. If, you received consulting help from anyone, please send me their name.

Sincerely,

Orin

H. Orin Halvorson
Professor

HOH:jr
Enclosure

P.S. At the Central Committee meeting I will consider the question of pulling out the underlined sections as a separate list to come at the end of the report.

I. THE MAINTENANCE OF THE HEALTH OF THE MILITARY AND CIVILIAN POPULATION

a. Environmental health and sanitation

b. Nutrition

c. Men, machines and environmental stresses

d. Non-specific factors involving resistence and infection

II. MENTAL AND PHYSICAL DEFECTS AND DISEASE PROBLEMS

a. Manpower availability through selective service

b. Morbidity and mortality data from the various wars

c. Respiratory diseases among the recruits

d. Diseases of military importance

III. BIOLOGICAL WARFARE

IV. MARINE BIOLOGY AND NATIONAL DEFENSE

V. DETERIORATION OF MATERIALS

VI. CIVIL DEFENSE

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BIOLOGY AND NATIONAL DEFENSE

PANEL 23

Basically the national defense of any country is dependent upon the country's natural resources, its industrial potential, and the mental acuity, physical health and will of its people. The last quarter of a century in the United States has been marked by depletion and deterioration of its natural resources, by a rapid and large expansion of its industrial capacity, and by the improvement in the educational level and general health of its people. However, the steadily mounting toll of human life in highway accidents offers tragic evidence that improvements in the mental acuity and manual dexterity of its people have not kept pace with the improvements in the machines.

The rapid increase of knowledge in the physical sciences with the concurrent technological developments in communications, transportation, and weaponry has claimed the lion's share of the attention of those responsible for National Defense for almost a quarter of a century. Tremendous improvements have been made in the machines and the weapons of warfare. Never before has the active fighting man been so well-equipped and so well-supplied. Even though advances in medical knowledge and first aid practices have greatly reduced our military losses from disease and battle casualities, it is apparent that this heavy emphasis on the physical sciences and the technology growing out of our increased knowledge of chemistry and physics has not been matched by a corresponding development in the technology growing out of biological knowledge. Just as man has not yet achieved a satisfactory level of control of the speed and the power of the automobile on our highways, so has man not yet achieved a satisfactory level of control of the speed and power of the modern weapons of war.

Modern technology has brought profound changes, not alone to our individual lives but to our civilization and the institutions associated with it. Most of these changes have been accepted eagerly, but others cause much concern. Those causing concern arise either because no attempt has been made to adapt the design of the machine to fit the mental and physical capabilities of those people who are to use the machine or due to the failure of our society to devise and support research and educational programs which would enable our citizens to adapt better to the new machines and the changes which they bring to our lives. Man is an adaptable animal, but there is grave concern as to whether man can adapt rapidly enough to meet the many challenges presented by the new technology. Man's ingenuity in devising machines has outstripped his ingenuity in devising way and means of developing in man the capabilities to master the machine and the environment which the machine creates. This is a matter of serious concern in our peacetime activities and may even become the critical determinant in the success of our National Defense.

Our defense in the final analysis depends on our people. The machines will be no better than the people who make them and they will operate no more effectively than the people who operate them. The imbalance is the application of the physical sciences versus those in the biological sciences are of concern in both the general peacetime welfare of our nation and in its national defense. Our report will concern itself with only those areas of special significance to national defense. These areas are:

I. The maintenance of the health of the military and civilian population

II. Mental and physical defects and disease problems

III. Biological warfare

IV. Deterioration of materials

V. Civil defense

I. THE MAINTENANCE OF THE HEALTH OF THE MILITARY AND CIVILIAN POPULATION

a. <u>Environmental health and sanitation</u>

We pride ourselves as a nation on the improvements in our environment which we have brought about that affects our health and well being. By making our drinking water supply safe we have all but eliminated several of our bacterial diseases; by maintaining disease free dairy herds and by sanitary control of our milk supply and other dairy products we have practically eliminated tuberculosis and other diseases spread by these food items. While all this is for the good, there are other subtle changes in our environment brought about by our increasing population, industrial activity, and our mode of transportation, that we cannot be proud of and which may well have an adverse affect on our nation's health. Although the increase in pollution of our water supply and of our air are not necessarily a matter that concerns national defense it does have an indirect bearing in that whatever affects our civilian well being does have an influence on our military posture.

In case of a national emergency due to military action there are some areas of our environment that can be of considerable importance to our national defense. Some of our large metropolitan areas are dependent on a single or very few pumping stations to supply the community with water. If

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some of these should be destroyed a safe water supply would certainly be jeopardized. Some communities would be hard pressed to get sufficient water to keep the population alive. We can get along without food for awhile but not without water. Under such conditions the citizens would have to fend for themselves in obtaining water and then from any sourceavailable even though highly polluted. While electricity, gas and other sources of energy are still available, the water could be rendered safe by boiling but if the energy sources are also disrupted chemical sterilizing agents would have to be relied upon to render this water safe for drinking. This could be a serious problem in that suitable chemicals are not readily available and the average citizen is not knowledgeable about their use.

The shutting down of the public water supply would also disrupt the normal disposal of human wastes, since our modern society depends on water to carry these wastes to a disposal area. With no running water we will have to resort to primitive means of disposal and this will certainly have an adverse effect on our environmental health.

Our modern food technology has provided us with a safe supply of food and has reduced considerably the incidence of food poisoning. In case of a national emergency brought about by military action we may be deprived of much of our modern equipment essential for this technology so we may be confronted with serious outbreaks of food poisoning and more food borne Salmonella infections.

The control of food poisoning and food borne infections is still a grievous problem in our military establishments both at home and abroad. The feeding of large groups of people always increases the difficulty of avoiding food poisoning and our knowledge of the organisms involved is still

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too meager to allow adequate control. The recent work on the isolation and characterization of the staphloccoccus toxin is an important step in this direction but much remains to be done.

We are involved in world wide military activities and this brings our troops into new types of environments that can affect their health and well being. Their environmental health will, therefore, be an important problem for our military command. Knowledge of world wide environmental health conditions is consequently more important now than ever before. It is recommended that an aggressive program in the collection, collation, and dissemination of information pertaining to environmental health be established and assigned to an appropriate federal agency.

b. Nutrition

In a National emergency the shortage of food for the armed forces and the civilian population can become a reality even in our affluent society and even more so now that our large surpluses have materially dwindled. In case of war on our own soil or an atomic attack, lack of food can become a serious problem. On the other hand if conflicts are confined to other lands, as has been the case in recent history, our food supply should not be a serious problem. The problems we face in these two contigencies are so entirely different that it is best to deal with them separately.

Barring an atomic holocaust or armed invasion we are able to provide food for our armed forces and civilian population. This capability has improved considerably during the past several decades because of advances in agriculture and food technology. The latter are due in no small part to the research and development efforts of the federal government. Advances in food technology have been responsible for the development of many of our processed and convenience foods that have improved the diet of our armed forces and found wide acceptance by the civilian population. Research sponsored and supported by the Department of Defense and by civilian agencies frequently with federal support has been responsible for many of the processed and convenience food items on the market today. These developments have improved greatly the food supply of our armed forces. Further efforts in this connection can effect still further improvements.

Considerable effort has been exerted on the use of radiant energy for the sterilization of foods. This is very laudable since it may make possible the preservation of many food items in a more wholesome and palatable condition for long term storage without refrigeration than has been possible in the past. One of the major problems here has been to overcome the deleterious effect radiation has on flavor and texture. Recent work has shown that food subjected to radiation at low temperature can be sterilized with minimal changes in flavor and texture but even these minimal changes must be prevented before a widely acceptable product is produced. It has not been possible however, to date, to destroy enzymes that are present even though the items can be sterilized. Consequently, if foods are to be preserved by irradiation for long periods of storage it is necessary currently to inactivate the enzymes by other means.

Before radiant energy sterilization can be approved for general use, an agreement must be reached regarding the level of initial contamination that needs to be overcome. When bacteria are killed by any physical process the viable population decreases according to a probability function, consequently the length of time required for any given treatment to effect sterility will depend upon the extent of initial contamination. An agreement on the extent of the initial contamination that must be overcome, is therefore essential. When a reasonable standard has been agreed upon, it may be possible that radiant energy sterilization of foods will come into general use for our armed forces and civilian population. This development is particularly important for the sterilization of foods that are injured by temperatures required to destroy contaminating bacteria. A good example of this would be cured pork products such as ham and luncheon meat. An acceptable process of radiant energy sterilization would make possible long term stockpiling of such perishable foods.

In nature, many of our foods are preserved by dehydration. To this we owe the keeping quality of grain, nuts and cereals. Although our attempts to preserve other foods by dehydration have been less successful, research has pointed the way to dehydrate successfully fruit juices, beverages, dairy products and some vegetable products.

Dehydration by lyophilization generally produces products that are satisfactory and easy to rehydrate when freshly produced but unfortunately they do not remain so on storage. Many such items including meats, undergo autooxidative changes in storage that render them unsatisfactory. In the past this has been believed to be due to the oxidation of contained lipids but more recent work indicates that other substances as well may undergo autooxidative changes. Much more basic research needs to be carried out before this difficulty can be overcome.

The great advantages of dehydrated foods is the saving of weight that is accomplished. This of course is important if foods have to be shipped over long distances. Meats and unground food items that are dried by lyophilization lose much of their weight but there is no corresponding reduction in volume. For long distance shipping reduction in volume may be as important as the reduction in weight. To accomplish this, compression is necessary but it remains to be seen whether such food can be successfully rehydrated. If the above problems can be solved it would greatly facilitate shipping to and stockpiling of these foods to remove areas of the world.

To sterilize food by radiation or heat or even to preserve foods through dehydration we must inactivate spore forming bacteria. We still do not understand the mechanisms responsible for the resistance of these organisms to radiation, heat and dessication. Even though our knowledge of these organisms has expanded greatly due to federal supported research, continued support is needed if we are ever to learn how to inactivate these organisms without resorting to excessive exposures to radiation, high temperatures or other environmental conditions which may injure the food itself.

In case of a nuclear attack or invasion of our shores we may be faced with some difficult problems in supplying food to our armed forces and civilian population. The very developments that have made possible the production of all of our processed and convenience foods, now a part of our civilian economy, compound our difficulties of supplying food to our population. The destruction of important food processing centers could seriously affect the quantity of these foods available on the market. The disruption of our transportation through nuclear attack would make it very difficult to distribute these and other foods even though they were available. We might not then be able to supply the armed forces and the civilian population with the kinds of foods they need. There would probably be a severe shortage of canned foods, if they are available at all, and destruction of our electric power supply would cut off much of our refrigeration. To compound these difficulties still further we are likely to be faced in the future with a situation where we no longer have on hand large surpluses of food such as grain and dairy products, thus making us dependent upon current production. Our past stockpiles of these foods have just about disappeared.

For a number of years the Department of Agriculture has been studying problems that are likely to be created by an atomic attack or by invasion of our shores. By setting into operation plans which they have formulated they undoubtedly will be able to control the situation somewhat. They will not, however, be able to prevent many serious difficulties that are bound to arise. Even though our agricultural capabilities would not be seriously affected by direct atomic attack we would still be faced with some serious problems. Our farms are highly mechanized, depending upon machineryand fuel. The destruction of our manufacturing facilities that would result from an atomic attack and the disruption of our transportation would make it extremely difficult for our farmers to replace worn out machinery and to get sufficient fuel to operate the machinery they have on hand.

<u>If we are to cope successfully with the problems that will be created following a nuclear attack we shall have to give much more serious thought to stockpiling of foods planned for emergency situations beyond those that are currently considered</u>.

The work done on nutrition in the past has concerned itself primarily with 1) the number of calories required to supply needed energy 2) the amount of proteins, carbohydrates and fats and minerals required to sustain growth and maintenance and 3) the amount of vitamins necessary for the proper functioning of enzymes. Even though these are the important facets of nutrition it is quite probable that there are other ways in which nutrition may affect a man's health and well being. Does nutrition influence a man's alertness, performance, and decision making? If so we should know a great deal more about this facet of nutrition. Modern technology is providing man with many machines and weapons operated electronically and requiring split second decisions on the part of the operator. Alertness is clearly required where pilots are handling aircraft, traveling at several times the speed of sound. Alertness is also required for the average citizen who is handling our powerful modern automobiles. The need for alertness, performance, and rapid decision making in modern warfare is so great that a strong research program in this field is justified, as an expenditure for national defense.

c. Men, machines and environmental stresses

Man is still in the process of learning to live with machines. Whether his rate of learning is keeping up with the rate at which machines develop is perhaps questionable. In any case, he must try his best lest the machines overwhelm him. Furthermore, modern transportation exposes people not only to close contact with machines, but subjects them to an ever increasing variety of environmental conditions at a more rapid pace than ever before. One day a man may be in a temperate climate living a routine life and the next he may be in a hot, humid climate working, say, with jet aircraft or he may find himself in the artificial and perilous position of a crew member of a deep submergence vehicle in the ocean.

History and statistics suggest that while death and disability from disease are gradually being brought under control in military situations, it is doubtful if the same is true for injury and disability related directly to high-energy machines and unusual environments. Certainly any device generating large concentrations of power is a definite hazard. A list of such devices would be very long and would certainly include internal combustion engines, jet engines, atomic devices and electromagnetic and acoustic power generators. Vehicles containing some of these may also provide a complex interaction of several such sources, for example railroad trains, aircraft, trucks, tanks, ships, submarines and spacecraft. Along with physical forces generated by high-energy devices, there may be exotic substances, some toxic, as well as sharp changes in ambient pressure, temperature and humidity. While all of these problems are important to society in general, they are particularly important to the Armed Forces because of the much more intensive use made of these high-energy devices and the much higher costs and risks associated with them and their operation. The design and construction of machines and vehicles must take into account the physiological tolerance limits of their operators and of maintenance people with regard to the environmental forces. This involves a rather detailed knowledge of many aspects of human biology. In addition, the behavioral and social sciences become heavily involved when one includes the problem of effective use of these machines, particularly under the conditions of stress. For example, modern high-speed aircraft not only expose men to low ambient pressure, cold, intense noise and vibration, and even radiation, but the complexity of operating these aircraft makes great demands on behavioral capacity.

Considerable effort has been spent and progress made in extending the 'motor function' of the military unit. To lesser extent, there has been an effort to increase man's sensory input through advanced engineering models which permit him to see and hear remotely. There is some reason to believe that a more careful anatomical-biophysical representation of the actual sensory systems which occur in nature might provide the blueprint for more advanced weapons systems of the future. The importance of developments in this area can hardly be underestimated when one considers the decision making which is required in the defense posture of modern military forces. Important as decision making may be in determining strategic or tactical operations, the success or failure depends to a considerable extent on the validity and timeliness of the information presented to the decision maker. Biology should be vitally concerned with this process as well as other disciplines related to the Life Sciences.

The problems of application of biological knowledge to defense problems are exceedingly complex. For example, the preparation of vehicles, weapons systems and procedures for their use often requires elaborate considerations of cost and time on the one hand and relative effectiveness and risk on the other. This type of analysis is particularly difficult to apply in situations where key information, in this case relating to biology, is missing. Research problems are not necessarily solved on schedule and important unpredicted results are sometimes obtained. Furthermore, while fruitful applications of research may take years to develop in the physical science, they may take a great deal longer in the biomedical areas, if only because the situation is so much more complex.

Necessary biological information is obtained not only from the current state of knowledge, but also from special studies directed toward particular situations as they develop. Progress in the accumulation of biological knowledge in general is more or less continuous but spurts of applied research are undertaken in response to immediate problems. Even in applied research however, the time required to obtain information of direct value and to apply it may be very long. This is particularly true since basic research results are not necessarily obtained in useful form and much applied research may then be needed to provide relevant numerical information for specific situations.

It should thus be clear that the application of biology to problems of national defense requires a strong research capability. Such a capability must extend well into basic research areas on the one hand and into applied studies on the other. Of course it is understood that we are referring here particularly to the areas involving the physiology, biochemistry, etc. of human beings. However, the problem is, of course, much broader, extending as it does into such areas as disease susceptibility or psychological stress. Considerable effort has been spent in studying performance activities of operators of highly complex machines. Beyond the purely behavioral aspects of this, there is good reason to believe that careful studies of sensory mechanisms would provide an important contribution not only for current systems but for the more advanced systems which the future will surely bring. A thoroughly adequate research program includes not only suitable facilities of which there appear to be many but also a sufficient number of skilled scientists of which there are perhaps not a sufficient number. Beyond this, there is a great need for effective communication between the biologists who provide the information and the engineers and operations people who consume it. This problem of communication is a serious one partly because of the widely different backgrounds and attitudes of the two groups and partly because of the problem of physical location, since the scientist tends to stick to the laboratory, the design engineer to the drafting room, and the operations man to the field. Clearly, a major aspect is that of the need for mutual education and confidence. It is almost essential that there be people available who have some knowledge of both sides.

Some of these problem areas may not have been adequately studied - as evidenced, for example, from current Viet Nam operations. While inadequacies arise partly from the difficulty of predicting exactly where the next set of urgent problems will arise, they may involve even more importantly the lack of an adequate resource capability. In particular, the funding of applied research tends to attach itself to urgent problems, but at the last minute and on a short term basis only. For example, studies on the effects of hot and humid environments tend to be dropped as soon as the emergency ceases, thereby weakening seriously a capability which may then have to be reconstructed for the next occasion.

The above comments should not be taken to imply that present activities are completely inadequate. There is strong support throughout the country for basic research in many biomedical areas and there are also a number of Government laboratories both in and out of the armed forces whose work has been essentially in both obtaining and applying the research material. However, there are areas in which environmental problems have not been as carefully studied as they should be and the effort needed for effective communication among biologists, engineers and operations people is still unnecessarily great. In the study of injury related to machinery and unusual environmental stresses, much has been done and much will continue

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to be done. However, the rapid increase in the overall rate of technological development offers the possibility of straining our resources for meeting emergencies. For example, many biomedical problems which have arisen out of the discovery of nuclear fission and its technological applications are still very far from being solved after 20 years. Problems now becoming important in the areas of deep sea submergence will require a much more extensive effort than is now being made. How soon further problems of comparable difficulty will arise is unpredictable. Every effort should be made to avoid being caught short.

d. Non-specific factors involving resistence and infection

The efficacy of immunization procedures for the prevention of a considerable number of infectious diseases is well known. The principle on which these procedures are based is the production of antibodies in the host (active immunization) by inoculation of the infecting agent or an extract or a product of that agent. Notable examples are the successes in preventing diphtheria by administration of diphtheria toxoid or of poliomyelitis by the administration of killed or living attenuated viruses. In most instances the immunity thus produced is a durable one, lasting for months or even years. In contrast, the protection produced by the administration of antibodies formed in another host, whether it be another man or an animal, is transietn, usually lasting for not more than 4-6 weeks, and thus has very little usefulness.

In contrast to the notable successes, however, there are many diseases which cannot be prevented by active immunization. In some instances the infective agent cannot be detoxified or inactivated to a point where it is safe to employ it; in others the disease itself does not confer immunity when it occurs naturally and resistance to infections does not follow artificial immunization with the infective agent. In still others the sheer number of antigenically different infectious agents is too large to make practical any immunization procedure. An example of this last category is found in the rhinoviruses which are common causes of mild upper respiratory tract infection and now appear to number more than one hundred antigenically and immunologically different types of viruses which show no cross immunity one-to-another. Moreover, the efficacy of some of our oldest vaccines is still not adequately established. An example is cholera vaccine which was the first bacterial vaccine to be used; another is typhoid vaccine. It is obvious that approaches other than active immunization are needed.

An approach which has been highly successful for certain diseases has been the use of a variety of chemicals and drugs for both the treatment and the prevention of infectious diseases. Sulfonamide drugs and penicillin are two examples of such drugs. They have been highly effective both therapeutically and prophylactically against certain bacterial and rickettsial agents and a few fungal and protozoal agents, but even here difficulties are being encountered. The capacity of the microbial agents, to mutate which in general have a generation time of minutes or hours, has led to the appearance or selection of resistant strains of organisms. Three examples may be given: the chloroquine-resistant strains of falciparum malaria, the penicillin-resistant strains of staphylococci and the sulfonamide-resistant strains of meningococci. This phenomenon of resistance means not only that new drugs should be sought, but that old ones should be re-tested. In general, chemo-therapy have not been effective against virus diseases. Recently, however, some success has been reported in the use of deoxyuridine compounds in herpes infections, thiosemicarbazone compounds in the suppression of smallpox after exposure and before the development of clinical symptoms, and the limited experience with adamantine in the prevention of the Asian type of influenza. At the present time these successes can be considered as no more than modest and work along these lines should be encouraged.

There is a third and much more difficult approach that has been discussed and investigated to a limited degree over the years, but now should be urgently pursued: Nonspecific factors involved in resistance to infection. It has long been known that certain animal species are resistant to infections to which other animals are susceptible. The nature of this "natural immunity" is unknown. It is also known that in man and other animal species there are a number of nonspecific reactions to infections that seem to be defense mechanisms of the host. One of these is the inflammatory reaction that ordinarly occurs at the portal of entry of the infectious agent and is usually characterized by increased capillary permeability, lowering the pH, infiltration of leucocytes with resultant phagocytosis, and the accumulation of circulating substances such as complement and properdin. Other nonspecific defense reactions such as fever and granuloma formation may also be cited as examples.

The the present time considerable attention is being given to a substance called "interferon". This substance is apparently a protein which is produced nonspecifically when cells are exposed to a variety of substances such as certain viruses, polysaccharides (Statalon), phytohemagglutinin, some mycoplasma organisms, extracts of some fungi, and certain synthetic anionic polymers. The action of the interferons so produced is species-specific in that it will prevent infection only in cells of the same species in which the interferon was produced. Interferon once produced is not specific for the inducing virus or substance, but will act on others indiscriminantly. Interferon is nontoxic, nonantigenic, and readily excreted in the urine, but also to some extent persists in the body for weeks or perhaps months. It is being tried prophylactically and therapeutically both by local applications and systemic injections. Under certain circumstances interferon seems to inhibit the clinical manifestations of infection but does not prevent subclinical infection and subsequent immunity. One of the major problems in evaluating interferon has been the difficulty of producing it in quantity from a human exogenous source so that adequate amounts can be administered either prophylactically or therapeutically in controlled trials. A more hopeful approach seems to be to stimulate the endogenous production of interferon and interferon-like substances by the administration of nontoxic and nonantigenic inducers of interferon synthesis to the host. For example, in anticipation of an epidemic of a virus disease of known or unknown etiology for which no effective prophylactic or therapeutic measures were available, such as occurred in the 1957 pandemic of Asian influenza, susceptible populations could be treated against the infecting agent with drugs which stimulate nonspecific hosts mechanisms, such as interferon.

The importance of these nonspecific factors is great and they may well provide the solution to otherwise insurmountable problems. Investigative work in this field should be stimulated by special funding, encouraged and supported.

II. MENTAL AND PHYSICAL DEFECTS AND DISEASE PROBLEMS

a. Manpower availability through the selective service

There is an enormous pool of data available on manpower rejection rates for selective service. Much of these data cannot be directly compared, for example, between World War I, World War II, the Korean conflict, and the current conflict in Viet Nam. The reasons are basically that the standards for acceptance vary depending upon the complexity of the machinery of war and that the total manpower requirements vary. Standards become less stringent when large numbers of soldiers are required as was the case in 1942 to 1944 in World War II. Nevertheless, there are some rather interesting trends which have been reported. Only the most significant changes in the availability of manpower are felt to be appropriate to this report.

During the early phases of World War II, approximately 50% of those examined for induction through the selective service were called for general duty. Another 25% were inducted for limited duty. During the later phases of World War II, the rejection rate for inductees rose to approximately 50%. Causes for rejection were primarily a variety of physical defects (approximately 90%) with only a relatively small rejection rate because of failure to meet the mental test standards. From the end of World War II to the present time, the overall rejection rate for inductees has continued to remain at the overall rejection rate for inductees has continued to remain at about the 50% level. However, the causes for rejection have shown a major change which the panel feels is highly significant.

By comparison, data obtained during the period 1964-1965 show that of the two million draftees forwarded to the armed forces for examination for induction, approximately half a million were disqualified for medical reasons and almost the same number failed to pass the mental test. Although the overall rejection rate has remained relatively constant, failure to meet the mental test standards (which accounted for 10% of the rejections in World War II) account for 50% of the rejections at the present time. It is also worth noting that the rejection rate for Negroes is approximately four times as high as for non-Negro draftees, the major reason being failure to meet the mental test requirements.

There are also marked geographic differences with respect to rejection rates. For example, there were nearly two and one-half times as many rejections among the inductees in the South as there were in the north central region of the country. There were also marked differences between states; for example, the rejection rate in Mississippi was nearly ten times that in the state of Iowa, primarily on the basis of the mental test. The point is that there are obvious differences in the rejction rate on both a geographic and ethnic basis.

Studies have been undertaken to determine the reasons for this high rejection rate. It should be pointed out that the mental test used in the selective service, system, the AFQT, is primarily designed to measure the examinee's general mental ability to absorb military training within a reasonable length of time and to provide some uniform measure of the examinee's potential general usefulness in the service. It is specifically intended to predict potential success in general military training and performance and was validated for that purpose. The AFQT differs somewhat from previous mental tests used by the services. A number of correlations were made to attempt to relate the AFQT scores with educational attainment.

If one compares the median scores on an ethnic basis alone, there seems to be no very significant difference with respect to education attainment. However, if one considers the data on the basis of geographic and ethnically differentiated groups, there is a very marked difference. In summary it appears as though the determining factors on mental rejection are not only related to the level of formal education and its quality but to interrelated socio-economic factors outside the school.

The causes for medical disqualification among inductees generally reflect major health problems found in the general population. However, there is an alarming increase in the rate of rejection on the basis of mental tests. Although this is not a problem confined to national defense alone, it is in one sense a measure of the overwhelming need for improved education, particularly in the socio-economically depressed areas. Data suggests that the relative rate of rejection on the basis of mental standards will continue to increase, probably in direct relation to the complexity of modern warfare. The panel endorses programs to improve education of the youth in socio-economically depressed areas and wishes to emphasize the importance which this has with respect to our national defense.

b. Morbidity and mortality data from the various wars

As mentioned elsewhere in this report, illnesses and deaths from disease and non-battle injuries exceeded those from battle casualties until World War II. Data for World War I and subsequent wars or conflicts regarding these points were made available to the panel only from the Department of the Army and are summarized in Tables 1 and 2. They are expressed as rates of occurrence per 1000 men per year so that they are comparable. Relatively few definitive conclusions can be drawn from these data. It is apparent the overall morbidity ("All admissions," Table 1) has declined since World War I, as have admissions to treatment facilities for disease and battle injuries. Non-battle injuries were approximately the same in World Wars I and II, rose somewhat in rate during the Korean conflict, but have been lower thus far during the Vietnamese conflict. The reasons for the latter reduction are not clear but may reflect the extent of utilization of motorized vehicles, since motor vehicle accidents are the chief cause of non-battle injuries. The reduction in disease morbidity rates may reasonably be attributed to the increased knowledge of and application of the principles of preventive medicine.

The data showing death rates are impressive. While the rates of total battle deaths and non-battle deaths were approximately the same in World War I, both have declined since then. In addition, the ratio between total battle deaths and non-battle deaths has become 2 to 3 to 1.

The above data, if they are applicable also to the Air Force, the Navy and the Marines, are encouraging, but they should give no cause for complacency. Our country cannot afford indefinitely the profligate expenditure of man. Better application of our present knowledge of the prevention and treatment of disease and injury, as well as of the logistics of these problems in war zones can be accomplished now. Further research in these areas, however, must be encouraged and supported.

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Table 1
Comparative Morbidity in Various Wars

Admissions per 1000 men per year to medical treatment facilities from the total Army

War	All Disease	Non-battle Injury	Battle Injury and Wound	All Admissions
World War I Apr. 1,1917-Dec.31,1918	946.82	76.72	71.74	1095.28
World War II 1942-1945	590.81	78.76	23.37	692.94
Korean Conflict July 1950-July 1953	486.30	84.69	19.49	590.48
Vietnamese Conflict July 1965-May 1967	267.71	41.16	11.56	320.43

Data from the Department of the Army, Office of the Surgeon General, Medical Statistics Agency 19 July 1967.

Table 2
Comparative Morbidity in Various Wars

Deaths per 1000 men per year in the total Army

War	Total battle Deaths	Non-battle deaths	All Deaths
World War I Apr. 1,1917-Dec.31,1918	16.17	17.89	34.06
World War II 1942-1945	9.27	3.05	12.32
Korean Conflict Julyl1950-July 1953	6.94	2.20	9.14
Vietnamese Conflict July 1965-May 1967	2.66	1.44	4.10

Data from the Department of the Army, Office of the Surgeon General, Medical Statistics Agency 19 July 1967.

c. Respiratory disease among recruits

Acute upper respiratory infections, influenza and pneumonia have long been leading causes of illness and of non-effectiveness among military forces. Except for epidemic influenza, which is cyclical and attacks seasoned men and recruits with equal frequency, the principal impact of these infections is seen among recruits. The most prevalent cause of recruit respiratory disease is now known to be one or another type of adenovirus. The most prevalent types have been 4, 7, 14, 21 and to a much less extent, type 3. One or more types may be prevalent simultaneously, but the predominance of a given type has varied in time and place. In North America, for example, types 4 and 7 have been most prevalent and types 14 and 21 have not been of importance. In Europe, however, types 14 and 21 have in certain years been the principal cause of epidemics. Such prevalence among the various types of adenoviruses may reasonably be expected to change in the future. Characteristically, high frequency of adenovirus disease occurs in the winter months, although sporadic infections occur throughout the year. The peaks of the outbreaks usually occur in the third to sixth week of training. Serological studies have indicated that from 60-90% of recruits will be infected during the winter months and about 10% in the summer months. About one-half of those infected have no clinically apparent illness, about one-quarter to one-third require hospitalization. Attack rates have been inversely correlated with length of military service and thus have been very low among cadre and at posts occupied only by seasoned troops. Susceptibility and resistance have been shown to correlate with the presence and absence, respectively, of type-specific neutralizing antibody. The reasons for the occurrence of epidemic

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adenovirus infection among recruits have not been clearly determined, since similar behavior has not been noted among the civilian population of comparable age. The illnesses are self-limited, recovery usually occurring in approximately 2 weeks, and fatalities are rare.

The commonest form of pneumonia occurring among recruits was initially termed "primary atypical pneumonia of unknown etiology." This illness, now known to be caused for the most part by *Mycoplasma pneumoniae*, occurs with one-tenth or less of the frequency of adenovirus infections, is a more severe illness clinically, but is rarely fatal. This form of pneumonia shows the seasonal variations of other respiratory infections but varies in incidence from place to place and year to year.

Other viruses known to cause acute upper respiratory infection are of relatively insignificant importance in military forces and insofar as is now known, do not cause epidemic outbreaks of febrile acute respiratory disease in recruits. The illnesses caused by most of them tend to be afebrile "nasopharyngitis" or "common cold" and although annoying, cause little time lost from duty.

Specific therapy is available only for cases of pneumonia due to *Mycoplasma pneumoniae* which respond promptly to the administration of antibiotic drugs of the tetracycline type.

Prevention and control of adenovirus infections and influenza can be accomplished by specific immunization, provided the appropriate types of virus are included in the vaccine, and in the case of influenza, possibly by chemotherapy using adamantine as indicated elsewhere in this report. There appears to be only one serological type of *Mycoplasma pneumoniae*; specific immunization is now being developed and evaluated and appears to be promising for future use. It seems likely at the present time, however, that immunization against mycoplasma infections will not be feasible except in focal outbreaks or at posts where the incidence is persistently high.

d. Diseases of military importance

Relatively few infectious diseases, whether spread directly or by insect vectors, are serious health hazards in the United States at the present time, because of a number of factors such as effective Public Health programs, improved sanitation, improved vaccines, early diagnosis and isolation. Some of the infectious diseases common in past years are becoming so rare that our medical students do not have the opportunity to observe actual cases. Our relative security from such diseases in this country makes us more or less insensitive to the situation that exists in other lands.

A few years ago we thought the malaria problem had been virtually solved and we could look forward to the day when this disease would be a thing of the past. The conflict in Viet Nam has shattered this view. The new strains of the malaria parasite encountered there make us aware that malaria is still a very serious problem for the populations in many countries and for our troops that may be stationed there.

Malaria is only one example of the neglected diseases that our troops encountered in foreign countries. Many, if not most, of these diseases have either been overlooked or neglected by our medical research scientists either because they were not aware of the existence of some of these diseases or because funds were not available for their study. Following are a few examples of infections that afflict our troups, infections we should know much more about before we commit troops to serve in areas where these infectious diseases are prevalent. Some of these diseases are not necessarily found only in other lands but are also prevalent in the United States, but because of effective control measures they may not be very wide spread and therefore further studies of them have more or less been neglected.

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Veneral diseases are a serious problem in many of the Asiatic countries where prostitution is very prevalent and is not being controlled by the local government. Gonococcal infections from antibiotic resistant strains are becoming more common, and these are complicated with Staphloccos infections in which the commonly used antibiotics are no longer effective. Scrub Typhus is not uncommonly found among the troops in Viet Nam and Taiwan. Better and less dangerous drugs are needed and we have yet to find a vaccine.

Bacterial and amoebic dysentery are two important diarrheal diseases that crop up quite often among the military even with the precautions for boiling water, peeling fresh fruit and not eating fresh meats and vegetables. The vegetables are often grown on land fertilized with night soil, though synthetic fertilizers are becoming more widely employed. Meats brought to the local market are not generally refrigerated or if they are, they are put on ice which is made from polluted water.

Haemorrhagic-dengue apparently is serious in Viet Nam although the haemorrhagic manifestations may not be as apparent in native populations who are repeatedly exposed to the disease. A reliable vaccine is needed to control this disease.

Japanese encephalitis is apparently a serious disease among the troops in Viet Nam and Thailand. A vaccine is being tried that is derived from a formalin-killed mouse brain antigen. Efficacy of this vaccine has not been fully documented.

Leptospirosis and cholera are also encountered in Viet Nam as well as Schistosomiasis in certain swampy areas.

Several Army and Naval medical research units are making very important contributions in their studies of many of the diseases that are being encountered by our troops in the Asiatic areas. Many of these units are working under severe handicaps, however, because of a large turnover in personnel, and in some cases because of insufficient funding for effective work.

While the examples given above are mainly for diseases that have been encountered by our troops in the Asiatic area, there are diseases in other parts of the world in which we might become involved in the future; and if and when we do, we will probably run into the same problems there that we have been in the Asiatic area by having to set up emergency units to study new diseases with which we are unfamiliar and for which we have no prevention or cure.

While many of the diseases which are of military importance are not necessarily tropical diseases, we have in the past used the term "Tropical Diseases" to designate most of these that are not particularly common in our own country. For this reason it is appropriate to call attention to a study entitled <u>Tropical Health - A Report on a Study of Needs and Resources</u>, which was published in 1962 by the National Academy of Sciences, National Research Council (NAS-NRC). In relation to our needs and resources at that time the report indicated we were suffering from a deficiency of trained personnel in this area and would continue to do so. The U.S. medical schools in 1959 had only 293 teachers of tropical medicine and parasitology and the total number of personnel engaged in research in this area in the government, private research institutions, medical schools and universities and drug companies was 507. It was noted that opportunities for securing advanced training in the USA were small. The advisory committee responsible for this report offered a series of resolutions, the most important of which was the establishment of an advisory organization within the NAS-NRC for a

National Program for Research in Tropical Health. This organization was not established. In the Annual Report 1962-63 of the Division of Medical Sciences, NAS-NCR, in relation to the recommendations of the Tropical Health Report it was stated that "Unfortunately no progress has been made toward the goal of a nationally conceived program of research in tropical health that was called for by the Committee. It is evident that the missions of the several operating government agencies involved are so individually oriented that it will be no easy task to achieve scientific and administrative coherence in programming. Nor is the time propitious. The critical attitude of Congress toward foreign aid is compounded by the deep concern of the administration with the imbalance of the gold flow." The situation today, is unchanged.

What has happened to tropical medicine in the "laissez faire" atmosphere of the intervening period? The Tropical Health Report used the membership of the American Society of Tropical Medicine and Hygiene as an index of interest in the field. In 1945 there were 1309 members, and in 1952 and 1965, respectively, 1074 and 1291 members. The Department of Defense has closed the Tropical Disease Laboratory in Puerto Rico. The work of the Laboratory of Parasitic Diseases at the National Institute of Health, one of the great laboratories for tropical medicine research, is decreasing sharply, and so is the work of the International Centers for Medical Research and Training, some of which have been closed down. Recent interest in malaria because of the occurrence of resistant strains in Viet Nam has resulted not in a marked expansion of tropical medicine as a whole, but in some reduction of programs on other tropical diseases.

In order to remedy the situation, some sort of coordinating agency is needed to provide more and better teachers in the medical schools. There should be provision for direct experience in the tropics for carefully screened students with a true interest in the field. More postgraduate training opportunities should be available, and finally, the ability to utilize the interest engendered and the training gained in the previous program for the development of careers in tropical medicine is absolutely essential. In relation to research in tropical diseases it should be pointed out that the developing countries are not putting the provision for health services at the top of their budgetary priorities, and within the health area, research cannot even be considered by a majority of these countries. The responsibility for research in tropical medicine thus devolves upon the developed countries. In summary, therefore, it is necessary to establish coordinated programs for the development of careers in tropical medicine from medical school onward and in the process to shoulder our responsibilities to expand our programs in research in tropical medicine.

III. BIOLOGICAL WARFARE

Over the centuries infectious disease has played an important, and in numerous instances, a decisive role in determining the outcome of individual military campaigns, and of entire wars. Until World War II deaths from disease exceeded those resulting from battle wounds in all wars in which the U.S. Army participated. For the first time in that latter conflict, scientific advances in the intervening years had provided a sufficiently improved basis for care of casualties that the incidence of death from disease declined. Among the most important of these scientific advances, incidentally, was the discovery of antibiotics by a biological scientist.

If we now turn our attention from mortality to a much more meaningful measure of loss of human productivity, namely morbidity, we again find that the loss of effective man-days resulting from disease by far exceeded those due to battle injuries in World War II. Indeed, even in present day civilian life, infectious diseases, primarily the respiratory diseases caused by viruses, are the major reason for absence of workers from factories and children from school.

While the preceding remarks are oriented largely to the attack on man by biological agents, it should be emphasized that both his crops and domestic animals are also susceptible to devastation from infectious disease. The destruction of food, the loss of economically important plant products such as fibers and oils, and the death or reduced productivity of livestock can result in major consequences to the health, welfare, and strength of a nation.

In the early part of World War II, in the months just preceding the entry of the United States into that conflict, and on a more urgent basis thereafter, a number of consultant committees were convened to advise on the feasibility and potentialities of Biological Warfare, and the threat it might pose to our nation. Most of the critically needed information required for clear-cut answers to these questions was not available at that time. Nevertheless, it was the considered scientific judgment of the members of these committees that an enemy nation could, with a concerted effort in the biological sciences, develop an effective weapons system based upon the purposeful introduction of infectious disease, and that BW represented a unique, novel, and potentially high significant mode of warfare which might pose a substantial threat to the United States. An active research and development program in BW was initiated in 1943 based upon these deliberations and their resulting recommendations.

In broad terms, the objectives of the research on BW have been to ascertain conclusively whether this mode of warfare is feasible, if so, to define its potentialities and limitations, to evaluate the threat it poses to our nation, and its armed forces in the field, and to develop appropriate defensive and other counter-measures.

It has been determined that some fastidious pathogenic microorganisms can be grown on an industrial scale and that these mass-produced organisms display many of the same qualities of virulence, stability, and susceptibility to chemotherapeutic agents, etc., that characterized the laboratory-prepared seed cultures and human cases from which they originated. Microorganisms isolated from naturally-acquired cases of infectious disease are the basic source of agents for investigation in BW research. However, extensive alterations in the characteristic qualities of these organisms can be achieved by appropriate genetic, nutritional, and biochemical manipulation.

Microbial aerosols travel downwind for considerable distances, and infection by the respiratory route occurs in certain instances, even though normal transmission is by a different route. Downwind travel of an aerosol is limited by the adverse effects of sunlight, relative humidity, oxidation, air pollutants, and many other factors which contribute to a loss of virulence or death of the organism.

The biological warfare research program has provided an affirmative answer to many of the basic questions upon which the World War II committees

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deliberated. Certain pathogenic microorganisms can be grown on an industrial scale, microbial aerosols can be generated that will travel many miles downwind, and, under suitable conditions, an infectious hazard can be created over large areas.

The threat of BW is sufficiently real to justify studying a variety of defensive measures. These have included instrumentation for detecting microbial aerosols and providing rapid warning so that protective steps could be initiated, evaluation of filters applicable to individual or collective protectors, and development of a number of gaseous or vapor-phase decontaminating agents. Medically oriented studies have focused on techniques for rapid identification of pathogenic microorganisms and improved methods for the diagnosis, treatment, and prophylaxis of those diseases that are of primary concern in BW.

Investigations have demonstrated that crop plants are susceptible to attack by either selected, biologically active chemicals, or pathogens that cause plant diseases. Chemicals are available that are producible on an industrial scale, that can be disseminated over wide areas, and that destroy plant growth by dessication or by disrupting normal growth activities. Plant diseases are known that, in nature, have spread over thousands of square miles and have caused widespread crop failures. The causative agents of these diseases can be prepared on a large scale and will cause infection of susceptible plant species as a result of airborne transmission. Detailed knowledge of the interrelationships of the pathogen and host, the rate and manner of disease development, and the damage resulting to the crop are all critical areas for study.

The BW research program was established to serve the defense needs of the nation. The conduct of the wide scope of research required to fulfill this mission provides a body of new information, much of which is suitable for publication in scientific journals or presentation at meetings of professional societies. Thus, in addition to accomplishing its primary mission in defense, the BW research program has made a number of significant contributions to the public welfare, health, and safety. A few examples follow.

Immunology. Vaccines, shown to be effective and safe in man, have been developed for a number of communicable diseases for which prophylactic agents were previously not available. These have included anthrax, botulism, Rift Valley Fever, Venezuelan Equine Encephalitis, and tularemia.

Experimental Airborne Infection. To a major extent, current information in this field of investigation is an outgrowth of the BW research program. From it have come equipment design, experimental procedures, interpretative concepts, and an array of information on the characteristics of microbial aerosols and experimentally induced infections. In addition, novel approaches are being applied to evaluate the role of the airborne route of transmission in the naturally acquired respiratory diseases which play such an important role in both civilian and military public health.

Safety in Medical Microbiology. The BW research program has pioneered in identifying the hazards involved in manipulating pathogenic microorganisms, and in developing building designs, equipment, and working procedures that will minimize or eliminate these hazards. These developments have been applied to the design of numerous pharmaceutical, public health institute, and university laboratories. A unique current application of this information regarding microbiological safety is in the design of the NASA Lunar Receiving Laboratory. This institution will receive and study specimens retrieved by the Apollo missions to the Moon in order to ascertain whether they have any unique or infectious hazard for live forms of Earth.

Vegetation Control. Early work with 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid in conjunction with the Department of Agriculture played a major part in the development of the weed and vegetation control technology now in widespread use in the agriculture of the United States and the world.

Physiological Specialization of _Piricularia Oryzae_. The BW program has made major contributions to the knowledge of specialization in _P. oryzae_, the cause of rice blase. This information is of great value in programs of breeding disease resistance in rice.

Plant Disease Epidemiology. Through development of techniques and instrumentation, the quantitation of host-pathogen behavior under field epidemiological conditions has been markedly improved. The incorporation of this information with physical measurements of the host's environment has led to improvements in the ability to predict behavior of plant disease epidemics.

Rinderpest Vaccine. The first highly effective vaccine for this contagious and fatal disease of cattle was developed in the early years of the BW program. The efficacy of the vaccine was demonstrated, and subsequently it was provided to several countries where rinderpest is an endemic problem.

The Defense Department has established a number of unusual facilities for the conduct of the research, development, production of agents, and testing required for a program in BW. These facilities are provided with extraordinary provisions for investigating highly pathogenic microorganisms with assurance of the safety of the workers involved and of the surrounding community. Many of these facilities are unique and permit experimentation that cannot safely be conducted elsewhere in this nation. These facilities are vital to the proper conduct of the BW program and should be upgraded periodically to take advantage of advances in technology.

The many valuable contributions of the BW program to scientific knowledge and to the public welfare deserve special recognition. Full support should be afforded to continuation of the practice of publishing in all instances unless military security considerations dictate otherwise.

In order to prepare an adequate defense against, BW, it is necessary to have a comprehensive and completely up-to-date understanding of the offensive capabilities of biological agents and weapons for their dissemination.

A continuing and vigorous research and development program must be maintained in both the defensive requirements for, and in the offensive potentialities of BW if this nation is (1) to understand fully the threat inherent in this mode of warfare, and (2) to provide maximal protection to its citizens from such an eventuality.

IV. MARINE BIOLOGY AND NATIONAL DEFENSE

The tremendous role played by the Navy in national defense makes it imperative to understand the Navy's environment, i.e., the sea. Oceanology, as it is now called, includes not only the study of the physical characteristics of the marine environment but to an equal degree, an understanding of its biological aspects. Marine organisms, from plankton to whales, produce many important effects. For example, they can interfere with underwater communications, drastically reduce the lifetime and effectiveness of equipment and produce hazards to people in the water.

Objects of any material, natural or artifical, submerged in the sea attract biological organisms in a remarkably short time. Although it is not proven, it is likely that the first settlers consist of bacteria and other minute forms which attach and form a slime on the material. Such a slime may be essential to the settling of other organisms. In any case fouling begins almost immediately after material is submerged in the water. The time before fouling is initiated, and the rate at which it accumulates depends on both seasonal and geographic factors. Ship's fouling is no longer a serious problem as it once was partly because of the speed at which most ships are underway and partly because of the availability of protective coatings. The problem, however, is far from solved, because other equipment is not so easily protected. Sonar domes, for example, cannot be painted and become inoperative with even small amounts of fouling. The struts of hydrofoil boats are equally susceptible to even minute amounts of fouling. Conduits, especially fire conduits, frequently foul while a vessel is in port; this fouling may be undiscovered until an emergency occurs at sea, and water is needed. While the biological organisms clogging the ducts can easily be killed with live steam and other chemical flushing, this does not solve the situation because the animals in many cases remain attached whether alive or dead. Persistent protective maintenance therefore is required. The loss incurred in dollars, time, and efficiency in operation amounts to billions of dollars annually.

In addition to fouling, a good deal of destruction is caused by biological organisms which bore into wood, concrete and other construction materials. Again, as in the case of the conduits, one of the major problems is the kind of boring which cannot be easily detected. Thus, pilings may appear sound from a superficial examination of the exterior while the interior is completely riddled by the tubes of the borers. This is because the entrance into the wood is made by the larval form which is nearly microscopic. While much money has been invested in the development of good creosotes, they are not effective against certain species of borers and other materials may be required to prevent this invasion.

Deterioration and general damage by biological organisms and their activities are not limited to fouling and boring, however, Many animals are attracted in a remarkably short time to artifacts placed in the water. If these are to be kept from too easy observation, they may be camouflaged or otherwise protected. The protection may be overlaid or destroyed, however, by visiting animals. Contrariwise, objects that are meant to be observed may be hidden by the camouflage of the fouling. In additiong to biologically produced visual changes, animals such as fishes which may be attracted to equipment in the water are frequently noise producers and can serve as clues to the presence of artifacts because of the concentrated population of animals producing sounds. Behavior patterns are also useful as clues revealing the presence of submerged materials. Octopods, for example, are known to burrow under equipment lying on the bottom and to mark the area around their "caves" with shells of their prey. A circle of white shells surrounding a dark object on the bottom marks it off quite clearly.

Larger marine forms must also be dealt with. For example, research on sharks is important for a variety of reasons. There is a continuing need for development of better means for protecting personnel from predaceous shark activity. It should be noted that shark repellents and/or deterrents are needed not only for reasons of survival at sea, but also as means of alleviation of the problem of interference by sharks in naval operations incident to hydrographic, hydrobiological, and even space research. Damage to cables, flotation gear, and re-entry packages associated with the recovery of space equipment at sea has been attributed to strikes by sharks. Harassment of swimmers, divers, and boat crews continues to result in interference with work-boat operations, the servicing of underwater equipment, undersea research, salvage, UDT operations, and recreational swimming. The need for effectively protecting men of the operating forces from shark attack was tragically demonstrated early in World War II and led to the hurried development of a shark repellent packet for use by survivors of sea disasters. Carefully controlled tests of this material in recent years by methods not available at the time of its development indicate that this packet, still issued as Navy Standard Shark Repellent, would probably not be effective at an acceptable level over the wide range of conditions encountered in present day global operations of the Navy.

Less apparent, yet very important in terms of a direct relationship to naval operations, is the need to understand the mechanisms by means of which sharks are able at relatively great distance to sense the presence of prey and to navigate in its direction with a high degree of accuracy. In so doing, the shark is able to collect and evaluate a variety of encironmental information in the form of chemical and physical stimuli under conditions of low signal noise ratio. The sense organis possessed by sharks for this purpose are yet to be fully identified, and even for those known to be present, the exact purposes and mechanisms of action are not at all well understood. It is clear that the shark possesses the ability to detect minute pertubations, and perhaps even potential gradients, in the water in such a manner to provide analysis of significance and directional information to the shark under conditions of relatively high background noise. When these systems are understood better, the geometrical patterns in which great numbers of sense organis are found on and just beneath the skins of sharks may be of great significance to those concerned with the development of submarine detection systems, underwater communications, and perhaps advanced fishing methods as well. Furthermore sharks have recently become quite important as "laboratory animals" in programs of study on biological processes related to normal and abnormal physiology and biochemistry.

The problem of interference with underwater communications has already been mentioned. It should be added since many marine organisms emit sounds, it is important to understand the identification of these sounds and to understand the circumstances and locations in which they are found. The marine biological problems in the above context involve ecological, physiological and behavioral factors as well as their interaction with geographic, seasonal and other considerations. While research, both basic and applied, has been carried out in these areas for a number of years, there are still many important problems which are far from solved and increased emphasis could well be placed in this area. The benefits to be derived are, of course, much broader than those of defense alone.

The research required to deal with these problems is considerably less expensive to the defense program than the losses in time, money and effectiveness.

V. DETERIORATION OF MATERIALS

New materials, particularly synthetics, and many modes of chemical treatment are materially reducing hazards of deterioration caused by micro-organisms. Research financed and carried out by the Department of Defense has made distinct contributions in this field. Even though the situation is much improved over that of a few decades ago, the ideal has not been achieved and further research is needed. During the two world wars we experienced a great deal of deterioration of electronic equipment because of high humidity and growth of fungi. The problem is being attacked through attention to design, based on exclusion of moisture. It entails selecting materials with minimum affinity for moisture and high natural resistance (indigestibility) to microbes.

Microorganisms have been known to modify our fuels to the extent that they are no longer suitable for airplanes. Sulfate-reducing bacteria generate hydrogen sulfide which on combustion produces sulfuric acid. Bacteria and fungi produce particulate matter that clogs filters and fine orifices. Almost always there is an obvious aqueous phase, and biological activity is greatest at the water-fuel interface. Sometimes the water is finely dispersed in the fuel, and the sampling procedure does not include the underlying layer of water. Both cases create the impression that the organisms can grow without water. In general, active microbial growth in a fuel system is a strong indicator that water-exclusion measures are inadequate.

Further studies are needed to describe and characterize the organisms that can metabolize hydrocarbon. The physiology of these microorganisms is very poorly understood and very few microbiologists concern themselves with it.

Microorganisms we know now decompose gasoline and fuel but recent work indicates that they can also decompose other petroleum products such as asphalt for roadbuilding. It appears that for all compounds produced by nature there are microorganisms capable of decomposing them. Therefore we need to be concerned about the biological deterioration in naturally occuring materials in whatever form they may be. This is particularly important in warmer climates where temperatures are nearly always favorable to the growth of these organisms. It is pertinent to national defense therefore that funds be made available for microbiologists to study the physiology of some of these "garden" organisms.

It has been estimated that the destruction of stored foods by insects, birds, rodents and microorganisms in the United States amounts to a loss of between six hundred million and one billion dollars per year. It is difficult to document this accurately, but in any event the loss is considerable, 30% of the loss being attributed to rodent infestation. The cost of destruction in other countries is, however, far greater, so much so that our foreign aid to India may only suffice to maintain their storage pest populations. The loss of stored food in Viet Nam from these sources is also considerable and it is possible that similar problems will arise in most areas of the world where we might become involved in a military way.

In the United States the consuming public is not satisfied with methods that kill pests that have already invaded our stored foods. They want foods that have never been infested so that it does not contain the bodies and residues of these pests. This places a premium on prevention and sanitation.

Ever since Silent Spring there has been a considerable expansion of effort in basic research directed towards the prevention of infestation of stored foods. The emphasis has been to build barriers against the infesting agents. This involves sanitation of storage areas, eradicating and then repelling the pests by means of chemical and nonchemical methods and the development of pest-proof packaging materials. It is important that funding for this type of research be continued.

Rice is known to be more resistant to insect damage than other cereals such as wheat and corn. This is, in part, because of the physical nature of the rice, which is so hard that insects cannot handle it. Because of this, rice can be stored in areas with relatively little damage while wheat stored in the same environment will be completely ruined. Recently questions have been raised as to whether or not it might be possible to select genetic variants of wheat that would have properties more like rice and would be more resistant to insect damage. This is an area where plant breeding geneticists could well make some important contributions. Research along these lines should be encouraged as should basic research on insect infestation of stored foods. With the ever increasing world population it is vitally important that we conserve what food is produced for humans rather than have it spoiled by these storage pests.

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VI CIVIL DEFENSE

The current medical civil defense effort is based upon a number of assumptions which include the unavailability of hardened shelters. As a result, only limited fallout protection will be available in the event of a massive attack. Analysis of the availability of physician survivors of an attack as well as available hospital facilities indicates that the rate of survivors will be dependent more on the availability of trained manpower than on any other single factor. Trained medical personnel, however, will be of little use without adequate supplies and equipment properly distributed. Some provision has been made for the stockpiling of hospitals, equipment and supplies. In any case, however, these supplies need to be renewed, relocated and expanded to provide a thirty-day supply of equipment, drugs, and the like. In spite of the relatively pessimistic view taken by many, it would appear that adequate supplies and equipment, if properly located, could save millions of lives in a nuclear attack.

It would seem prudent to increase the number of personnel who could provide some form of medical assistance during the post attack period. Various civil defense agencies at the federal and local levels have undertaken a number of training programs for the civilian population. Indeed, approximately two million people are now receiving some form of civil defense training. Nevertheless, it is quite clear that most of the civilian population, either because of apathy or other reasons, have not chosen to take advantage of civil defense training. Experience to date would indicate that simply augmenting the number of courses available on a voluntary basis is not likely to increase the number of trained civilians. It is unlikely

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that some form of compulsory training would be acceptable to the population at large unless such a program was integrated into current education programs.

The availability of food, water, and sewage disposal are of great importance with respect to post attack survival. The Department of Agriculture and a number of other agencies have been given responsibilities in terms of civil defense. With respect to food, the Department of Agriculture has set up an extensive program at the federal, state, and local levels. Personnel who make up this organization are equipped and trained to carry out radiological monitoring, food inspection, water inspection, and to assist the local population in obtaining critical food items. The panel feels that there are not adequate stockpiles of food currently available. It must be kept in mind that large reserves of cereal grains have been depleted over the past few years. Concurrently, the food industry, because of technological advances and better distribution methods, tend to maintain lower inventories. As a result, there is serious doubt that food supplies available in a post attack situation would be adequate for the majority of the survivors.

It is recommended that the federal government explore ways in which medical civil defense training might be made available more generally to young people, perhaps in conjunction with current programs on physical fitness. It is further recommended that the status of food supplies available in a post attack situation be reviewed carefully.

Members of Panel #23

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